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Procedia Social and Behavioral Sciences 2 (2010) 4407–4411

Procedia
Social and Behavioral Sciences

WCES-2010

An argument for a paradigm shift in the science teaching process by means of educational software

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Received November 4, 2009; revised December 7, 2009; accepted January 19, 2010

Abstract

This paper stands up as an argument for a paradigm shift in the science teaching process. The main goal of the authors is to point out ways of achieving learning excellence by usage of modern educational means. This bold aim can be reached by resorting to educational software within the teaching and evaluation processes. We will make our point making an appeal to a number of specific educational software, among which The Science of Music, Mechanical Oscillations, Fluid Mechanics, and Special Relativity. This kind of projects can develop links between physics and mathematics, physics and chemistry, physics and biology, or even between physics and music, providing outstanding results in the teaching process.

Keywords: Outstanding achievements; educational software; paradigm shift; learning excelence.

1. Introduction

In an active and interactive teaching and learning process, the student is no longer a passive receiver of knowledge processed and spread by the teacher. Contrarily, the student becomes an active person which, guided by teachers, discover and scrutinize new knowledge territories. The main goal in an active and interactive teaching-learning process must be to help the students to discover the pleasure of inquiry and learning, which leads to increase confidence in their forces. The usage of modern technologies and educational software is a must of the modern educational process. [1] We will make our point making an appeal to a number of specific educational software, among which The Science of Music, Mechanical Oscillations, Fluid Mechanics, and Special Relativity, all made in "Tudor Vianu" National High School of Computer Science, Bucharest, as a result of a very good collaboration between teachers and students.

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doi:10.1016/j.sbspro.2010.03.702

2. The advantages of educational software usage

The advantages offered by the educational software include unconventional tests allowing for an optimal feedback, user-friendly working environments, individual and/or team work, stimulation of the creativity and of the competition spirit by pursue of different modules, visual support which gives rapid understanding of even the most subtle and complex scientific themes.

For a more intense involvement of each student into the learning process, the educational software provides animation and the possibility to replay. This kind of activities allow the student to learn by playing, by varying different parameters and quantities in a rigorous, mathematical way, because mathematics, creativity, logic and originality are all needed to improve technology. [2]

3. Educational software developed in "Tudor Vianu" National High School and links between different fields of sciences

On the one hand, the computers offer the power to perform computation that is very long. The computers' graphic capabilities make them useful in designing devices and in simulating complicated processes. [3] On the other hand, science content must be embedded in a variety of curriculum patterns that are developmentally appropriate, interesting and relevant to student's lives. The program of study in science should connect to other school subject. The curriculum must put more emphasis on conecting science to other subjects, such mathematics, chemistry, biology, even music, less emphasis on treating science as a subject isolated from other school subjecs. The modern science curriculum should be coordinated with the mathematics curriculum in order to enhance the student's usage and understanding of mathematics in the study of science. [4]

Regarding the above statements, we will provide an example of links between physics and mathematics, using the "Oscillations" educational software. It is designed for students studying this mechanics phenomenon, with the intent to present them with an analogous mathematical model and with a broader view on oscillations extended to optical and heat phenomena. The software conveys information on harmonic oscillatory motion, including phasor diagrams, energy, the superposition of parallel oscillations having the same or different frequency, the superposition of perpendicular oscillation having the same or different frequency, and examples of oscillatory motion, chosen from all the fields of classical physics: optics, electricity, mechanics, and thermodynamics. This educational software is entirely interactive. Its main plus is the quality of simulations, which includes the actual oscillator which accurately moves according to the parameters specified by the student. Beside the oscillator there is a real-time graph illustrating the physical quantities which characterize the motion. For a better understanding of the phenomenon, the simulation can be paused at any moment. The student can easily correlate between physical parameters, having the liberty to compose his or her own representation, thus involving him or her into the learning process, an optimal possibility for the student to learn while playing, by varying parameters in a rigorous, mathematical way.

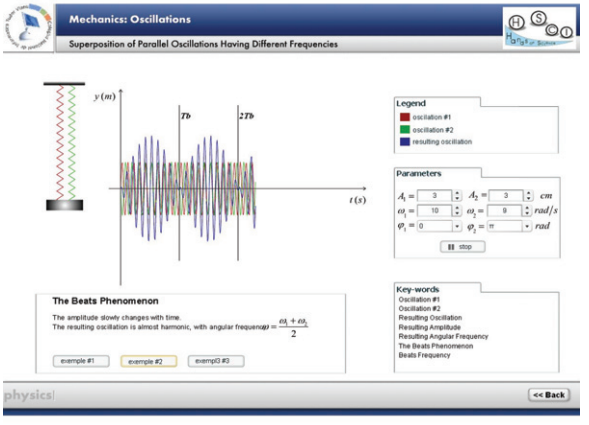

Figure 1. A screenshot from the Oscillations educational software

Science of Music is an educational software which offers a journey in the world of music guided by the laws of physics, thus managing to observe the regularities that appear. The starting point for this project was a passage from a book written by the well-known physicist Richard Feynman, "The Character of Physical lows". After reading what Feynman said, the idea of showing how harmonies recorded by our senses can be translated into mathematical equation came to us.

The application is designed for those who study physics, music, or both, and it's useful also as an auxiliary material for student class preparation. It is structured so that the user fully understands the mathematical laws and practical applications of physics in music. It is divided in six sections: theory, piano, guitar, other instruments, game and test. The Theory section is divided in two types of lessons: a „classical lesson" which consists of mathematical demonstrations and physical laws, and an „unconventional lesson" which presents the link between physics and music in a funny way.

The visual support enables the understanding and fast connection between the physical and musical phenomena. Many hours of explanations are reduced to a few minutes. [6]

The application is entirely interactive, being attractive even for those who are not really interested by any of the two subjects.

The software contents a virtual piano and a virtual guitar. It enables the user to interact with this kind of musical instruments. He or she can see how the musical notes are distributed on the piano, hear them while playing the piano and understand the science behind both the physics and the music. [7]

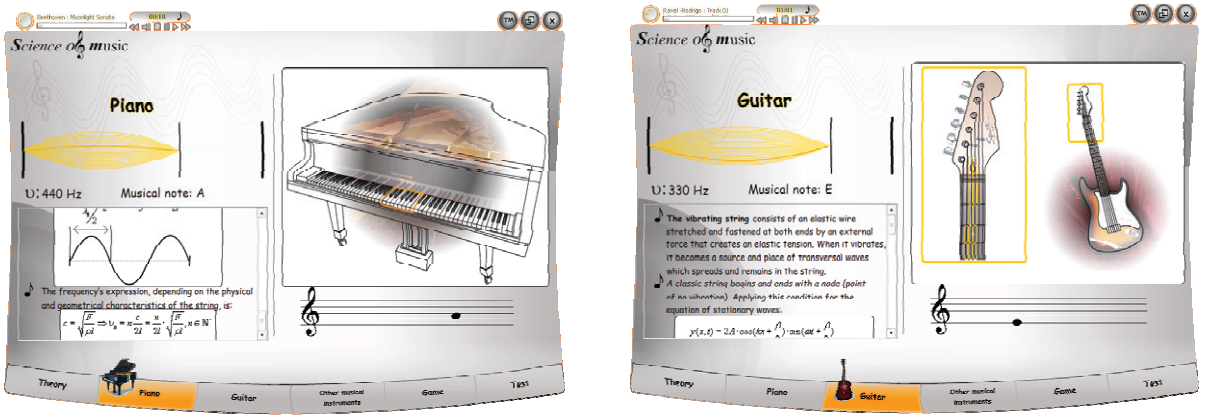

Figure 2. Two screenshots from the Science of Music educational software

In the 9-12 grades, the students can understand better the working to the circulatory system of the human body, using, for instance, the Fluid Mechanics educational software. This entirely interactive program contains such notions as hydrostatic pressure, Pascal's Law, Arhimede's Law, Poiseuille's Law and Bernoulli's Law. The most attractive part of the project, in our opinion, is the real life applications: the Magus Effect, the Coanda Effect, the aerodynamics notions, and the human circulatory system presented as a game.

The software is useful for those who study biology and/or physics. Its main objectives are:

- revealing mathematical regularities behind the dynamics of flowing phenomena;
- acquiring interdisciplinary transfers in the study of fluids and biology;
- developing a proper use of formal languages (mathematics, physics and biology);
- establishing connections between various specific physical quantities, mathematical expressions and theoretical biological notions;
- investigating pattern and symmetries present in the real world but visible only with the eyes "of the mind", namely physical laws.

Figure 3. A screenshot from the Fluid Mechanics educational software

The educational software allows the investigation, in the virtual lab, of some physics phenomena that "contradict" our human perceptions. For example, The Special Relativity software presents a sensible and revolutionary physics subject in an attractive, accessible, yet rigorous manner. Just like everybody, the students are amazed when they find out which the real laws that govern our universe are, and especially what implications they have. This entirely interactive application makes it easier for them to familiarize with the phenomena in Einstein's relativity. Many hours of explanations are condensed into a few minutes of activity. The visual support offers a rapid understanding of this phenomenon. This way of learning has a big advantage: the flexibility, the fact that each student can set his or her own pace of study.

Figure 4. A screenshot from the Special Relativity educational software

The educational software contains such subjects as the shrinking of the lengths and the stretching of the durations, relativistic effects on the geometric shapes, elementary particles in an accelerator, the light hyper-cones and Sun's death, and a Martian dinner. Many predictions from Einstein's theory of relativity have been confirmed on both atomic and astronomical scales. Our educational software also allows links between physics, chemistry, and mathematics.

4. Conclusions

The enhancement of student-student and student-teacher communication skills will raise the interest of the partners in education. This way, the lesson focused on the student becomes reality, the student as well as the teacher being interested in the outcome of the didactic activities. [8]

A modern teaching process must give the students many quality and modern resources, including educational software. We have always had the desire to offer more than usual text book can offer us, to go beyond what one studies at school in some subjects, to combine fields. These applications give us this opportunity! On the one hand, these educational software can be used very well in classes, to improve the lessons. One the other hand, they invite the students to find out more by individual study, exploring the interactive lessons and taking the challenges, the games and the tests. We wanted to test the impact that this software's utilization has on the students. We invited them to try it and then we asked them to complete a survey. Below one can see some results.

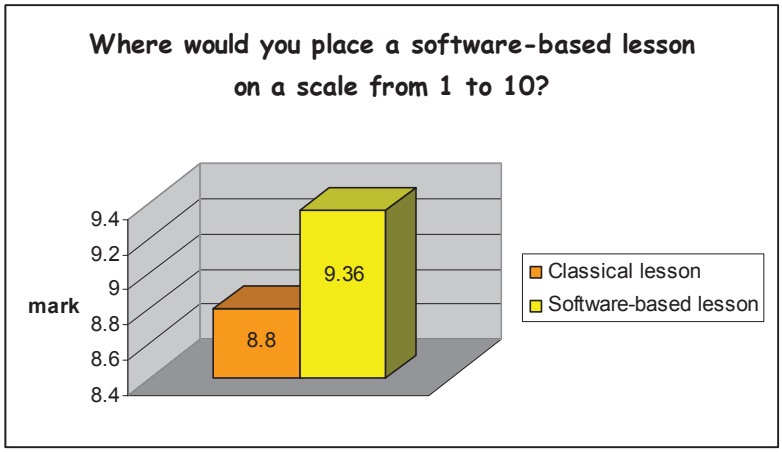

Figure 5. A survey for assessing the educational software

We argue for a paradigm shift because the traditional teaching methods cannot deal appropriately with the avalanche of new knowledge and with the accentuated dispersion of the activity domains and jobs. We are not pleading for a rebuttal of the traditional teaching methods, especially in the first years of school, when the personal touch of the educator remains of most importance, but we strongly believe that the usage of modern technologies and educational software is a must of the educational process, an addition to the classical methods, appealing to the individual character of each student.

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